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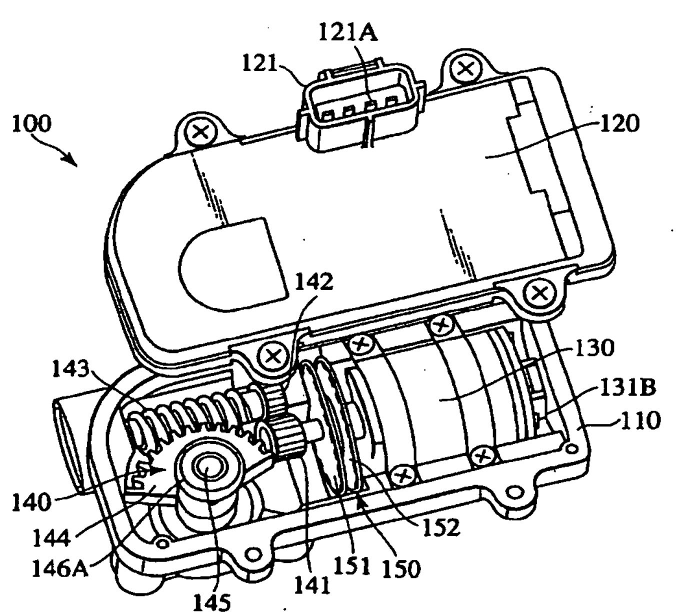
(54) Electronically controlled actuator

(57) An electronically controlled actuator for controlling a turbocharger is provided. A motor (130), a speed change mechanism (140) and a position sensor (150) are contained in a case consisting of a body (110) and a cover (120). The driving force of the motor (130) is transmitted through the speed change mechanism (140) to an output shaft (145) to drive the movable vanes of a turbocharger for turning. A first bearing (146A) supporting the output shaft for rotation is held on the cover (120), and a second bearing supporting the output shaft for rotation is held on the body (110). The position sensor (150) is mounted on the output shaft of the motor (130). The reliability of the actuator is improved.

FIG.1



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Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to an electronically controlled actuator, and more particularly, to an electronically controlled actuator suitable for the positional control of the movable vanes of a variable-capacity turbocharger for an automotive internal combustion engine.

[0002] A prior art electronically controlled actuator disclosed in, for example, EP-A No. 109088/1999 includes a motor and a speed change mechanism. In this prior art electronically controlled actuator, one end of an output shaft included in the speed change mechanism is connected to a driven member and the other end of the same is provided with a position sensor. The position sensor measures the present working position of the actuator and provides data to be used for the feedback control of the working position. The output shaft is supported for rotation in two bearings. The motor and the speed change mechanism are held in a case having a body and a cover.

[0003] Since one end of the output shaft of the speed change mechanism of this prior art electronically controlled actuator is used for transmitting driving force to an external device and other end of the same is provided with the position sensor, both the two bearings supporting the output shaft for rotation are disposed in the body at a small interval and hence the inclination of the output shaft increases. Consequently, 1) vibration resistance is reduced and 2) errors are introduced in measured positions due to an increase in the vibration of the position sensor.

[0004] First, the increase in the inclination of the output shaft increases the vibration of the output shaft in directions perpendicular to the axis of the output shaft. Consequently, fretting abrasion occurs in surfaces in contact under pressure of the speed change mechanism comprising a worm gear and a worm wheel, which shortens the life of the actuator.

[0005] Secondly, if the output shaft of the actuator shakes while the driven member is at a standstill, the output of the position sensor varies. Although the driven member is at a standstill at a normal position, the variation of the output of the position sensor is considered to indicate that the driven member is moving and a control signal to drive the driven member is provided. Consequently, the driven member is operated wrongly. Thus, the reliability of the actuator is reduced.

SUMMARY OF THE INVENTION

[0006] Accordingly, it is an object of the present invention to provide a highly durable, reliable electronically controlled actuator for controlling a turbocharger.

(1) With the object in view, the present invention provides an electronically controlled actuator for driving a driven member for rotation comprising: a motor; a speed change gear including an output shaft driven by the motor and capable of driving the driven member; a position sensor; and a case including a body and a cover, and containing the motor, the speed change gear and the position sensor; wherein a first bearing supporting the output shaft for rotation is held on the cover, a second bearing supporting the output shaft for rotation is held on the body, and the position sensor is attached to the output shaft of the motor.

Since the position sensor is attached to the output shaft of the motor, measures the turning angle of the output shaft of the motor to control the output shaft of the actuator, the vibrations of the output shaft are not transmitted to the position sensor and hence the reliability can be improved. Since the two bearings are mounted on the body and the cover, respectively, the two bearings can be disposed at an increased interval. Therefore, the vibration of the output shaft can be limited to the smallest possible extent, fretting abrasion can be limited to the least possible extent, and the reliability can be improved.

(2) The present invention provides an electronically controlled actuator for driving a driven member for rotation comprising: a motor; a speed change gear including an output shaft driven by the motor and capable of driving the driven member; a position sensor; and a case including a body and a cover, and containing the motor, the speed change gear and the position sensor; wherein a power supply connector for supplying power to the motor is formed on the cover, a bearing held on the cover supports one end of the output shaft, and the driven member is a turbocharger.

Since the cover is provided with the power supply connector for supplying power to the motor, and the bearing supporting one end of the output shaft, the cover serves also as both the connector and the bearing.

(3) The present invention provides an electronically controlled actuator for driving a driven member for rotation comprising: a motor; a speed change gear including an output shaft driven by the motor and capable of driving the driven member; a position sensor; a case including a body and a cover, and containing the motor, the speed change gear and the position sensor; wherein connecting terminals to be plugged in and connected to power supply terminals formed on the motor are formed on the cover, a bearing held on the cover supports one end of the output shaft, and the driven member is a turbocharger.

Since the cover is provided with the connecting terminals to be plugged in and connected to the power supply terminals formed on the motor, both supporting the output shaft in the bearing and elec-

trical connection of the connecting terminals to the motor can be simultaneously achieved by attaching the cover to the body.

(4) The present invention provides an electronically controlled actuator for driving a driven member for rotation comprising: a motor; a speed change gear including an output shaft driven by the motor and capable of driving the driven member; a position sensor; and a case including a body and a cover, and containing the motor, the speed change gear and the position sensor; wherein a motor control circuit is attached to the cover, a bearing held on the cover supports one end of the output shaft, the cover is provided with a partition wall separating the bearing from the control circuit, and the driven member is a turbocharger.

Since the motor control circuit is attached to the cover and the bearing held on the cover supports one end of the output shaft, and the cover is provided with the partition wall separating the bearing from the control circuit, the control circuit attached to the cover can be protected from contamination with a lubricant lubricating the bearing supporting the output shaft.

(5) The present invention provides an electronically controlled actuator for driving a driven member for rotation comprising: a motor; a speed change gear including an output shaft driven by the motor and capable of driving the driven member; a position sensor; and a case including a body and a cover, and containing the motor, the speed change gear and the position sensor; wherein the position sensor is mounted on the output shaft of the motor coaxially with the output shaft, the driven member is a turbocharger, and the angular position of the movable vanes of the turbocharger is controlled on the basis of the output of the position sensor.

Since the position sensor is disposed coaxially with the output shaft of the motor, the angular position of the movable vanes of a turbine included in the turbocharger is hardly affected by disturbances (temperature and vibration) and can be accurately measured, and the angular position of the movable vanes of the turbocharger can be accurately controlled.

(6) The present invention provides an electronically controlled actuator for driving a driven member for rotation comprising: a motor; a speed change gear including an output shaft driven by the motor and capable of driving the driven member; a position sensor; and a case including a body and a cover, and containing the motor, the speed change gear and the position sensor; wherein the output shaft has opposite ends supported in first and second bearings, respectively, the driven member is a turbocharger, and the angular position of the movable vanes of the turbocharger is controlled on the basis of the output of the position sensor.

Since the opposite ends of the output shaft are supported in the first and the second bearing, respectively, the vibration of the output shaft can be limited to the least extent, fretting abrasion can be limited to the least extent and the reliability can be improved.

(7) The present invention provides a turbocharger with electronically controlled actuator comprising an electronically controlled actuator comprising a motor, a speed change gear including an output shaft driven by the motor, a position sensor, and a case including a body and a cover, and containing the motor, the speed change gear and the position sensor; and a turbocharger having movable blades; wherein the output shaft has opposite ends supported in first and second bearings, and the angular position of the movable vanes of the turbocharger is controlled on the basis of the output of the position sensor of the electronically controlled actuator.

Since the opposite ends of the output shaft are supported in the first and the second bearing, respectively, and the angular position of the movable vanes of the turbocharger is controlled on the basis of the output of the position sensor of the electronically controlled actuator, the reliability of the turbocharger with electronically controlled actuator can be improved.

(8) The present invention provides an electric actuator comprising: a body; a motor held on the body; an output shaft; a gearing for transmitting the rotation of the output shaft of the motor to the output shaft to drive the output shaft for rotation; a bearing held on the body and supporting one end of the output shaft; and a resin cover fixed to the body so as to cover the motor, the gearing and the other end of the output shaft; wherein the cover is provided with a power supply connector for supplying power to the motor on its outer surface, and terminals electrically connected to the power supply connector and to the motor on its inner surface, and a bearing has an inner race fixedly mounted on the other end of the output shaft and an outer race fixed to the cover.

Thus, the resin cover serves also as both an electric connector and a bearing holder.

(9) The present invention provides an electric actuator comprising: a body; a motor held on the body; an output shaft; a gearing for transmitting the rotation of the output shaft of the motor to the output shaft to drive the output shaft for rotation; a bearing held on the body and supporting one end of the output shaft; and a resin cover fixed to the body so as to cover the motor, the gearing and the other end of the output shaft; wherein the resin cover is provided with electric terminals capable of being plugged in and connected to the power supply terminals of the motor and combined therewith by molding, and with a bearing holding part for holding an outer race included in a bearing having an inner race fixedly

mounted on the other end of the output shaft.

Thus, the output shaft can be supported and the motor can be electrically connected to the electric terminals by attaching the resin cover to the body.

(10) The present invention provides an electric actuator comprising: a body; a motor held on the body; an output shaft; a gearing for transmitting the rotation of the output shaft of the motor to the output shaft to drive the output shaft for rotation; a bearing held on the body and supporting one end of the output shaft; and a resin cover fixed to the body so as to cover the motor, the gearing and the other end of the output shaft; wherein a control circuit for controlling the motor is attached to the inner surface of the resin cover and is electrically connected to a connector formed on the outer surface of the resin cover, and the resin cover is provided with a partition wall holding an outer race included in a bearing having an inner race fixedly mounted on the other end of the output shaft and separating the control circuit from the bearing.

Thus, the control circuit attached to the resin cover can be protected from contamination with a lubricant lubricating the bearing supporting the output shaft.

(11) The present invention provides a movable-vane turbine comprising: movable vanes; and an output shaft driven for rotation by a motor and capable of controlling the angular position of the movable vanes; wherein a magnetic encoder is combined with the output shaft of the motor, the angular position of the movable vanes is physically controlled such that the angular position of the movable vanes varies as a function of the number of output pulses provided by the magnetic encoder.

Thus, the angular position of the movable vanes of the turbine can be accurately controlled regardless of disturbances (temperature and vibration).

(12) The present invention provides a movable-vane turbine comprising: movable vanes; a motor; an output shaft driven for rotation by the motor and capable of controlling the angular position of the movable vanes; a gearing for transmitting the rotation of the output shaft of the motor to the output shaft to drive the output shaft for rotation; a body holding the motor and provided with a bearing supporting one end of the output shaft; and a resin cover fixed to the body so as to cover the motor, the gearing and the other end of the output shaft; wherein a magnetic encoder is combined with the output shaft of the motor, a control circuit for controlling the motor is attached to a part opposite to the magnetic encoder of the inner surface of the resin cover and is connected electrically to a connector formed on the outer surface of the resin cover, and a magnetoelectric conversion device for measuring the variation of the magnetic flux of the magnetic encoder is attached to the control circuit.

Thus, the functions of both the control circuit for controlling the motor of the actuator of the movable-vane turbine and part of a rotation sensor are available.

(13) In the movable-vane turbine stated in item (12), the resin cover is provided with a partition wall for separating the magnetoelectric conversion device from the magnetic encoder.

Thus, the contamination of the magnetoelectric conversion device with grease lubricating the bearings and powder produced by abrasion can be suppressed.

(14) In the movable-vane turbine stated in item (12), the electric terminals of the motor, and a bearing mount for supporting a bearing supporting the other end of the output shaft are formed on the inner surface of the resin cover on the opposite sides of the control circuit, respectively.

[0007] Thus, the resin cover is able to hold the control circuit for controlling the motor of an actuator for the movable-vane turbine, part of a rotation sensor, and the bearing.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] Other objects and advantages of the invention will become apparent from the following description of embodiments with reference to the accompanying drawings in which:

Fig. 1 is a perspective view of an electronically controlled actuator in a preferred embodiment, in which a cover is separated;
Fig. 2 is a perspective view of the electronically controlled actuator in the preferred embodiment;
Fig. 3 is a perspective view showing the interior of a cover included in the electronically controlled actuator in the preferred embodiment;
Fig. 4 is a sectional view of the electronically controlled actuator in the preferred embodiment;
Fig. 5 is a perspective view of a variable-capacity turbocharger provided with the electronically controlled actuator in the preferred embodiment;
Fig. 6 is an exploded front elevation of the variable-capacity turbocharger provided with the electronically controlled actuator in the preferred embodiment showing the arrangement of vane links in a turbine housing;
Fig. 7 is a view showing the arrangement of variable vanes of the variable-capacity turbocharger provided with the electronically controlled actuator in the preferred embodiment;
Fig. 8 is a sectional view taken on line X-X in Fig. 7; and
Fig. 9 is a view showing a system including the var-

iable-capacity turbocharger provided with the electronically controlled actuator in the preferred embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0009] An electronically controlled actuator in a preferred embodiment according to the present invention will be described with reference to Figs. 1 to 9.

[0010] First, the construction of the electronically controlled actuator in the preferred embodiment will be described with reference to Figs. 1 to 4.

[0011] Fig. 1 is a perspective view of the electronically controlled actuator in the preferred embodiment, in which a cover is separated. Fig. 2 is a perspective view of the electronically controlled actuator in the preferred embodiment. Fig. 3 is a perspective view showing the interior of a cover included in the electronically controlled actuator in the preferred embodiment. Fig. 4 is a sectional view of the electronically controlled actuator in the preferred embodiment. In Figs. 1 to 4, the same reference characters designate the same parts, respectively.

[0012] Referring to Fig. 1, the electronically controlled actuator 100 in the preferred embodiment comprises a body 110, a cover 120, a motor 130, a speed change mechanism 140, and a position sensor 150. The motor 130, the speed change mechanism 140 and the position sensor 150 are arranged in a space between the body 110 and the cover 120.

[0013] Bands and screws fasten the motor 130 to the body 110. A power supply connector 121 is formed integrally with the cover 120. The motor 130 is a dc motor with brushes by way of example.

[0014] The speed change mechanism 140 comprises a pinion 141, a gear 142, a worm 143, a worm wheel 144, and an output shaft 145. The pinion 141 is fixedly mounted on the output shaft of the motor 130 by press fitting. The pinion 141 and the gear 142 are engaged. The gear 142 and the worm 143 are integrally formed of the same material in a coaxial arrangement. The gear 142 and the worm 143 may be separately formed of different materials, respectively. If the gear 142 and the worm 143 are formed separately, the same may be coaxially bonded together with an adhesive or the like.

[0015] The worm 143 and the worm wheel 144 are engaged with each other. The output torque of the motor 130 is transmitted from the pinion 141 to the gear 142 to lower or raise the output rotating speed. The rotation of the worm 143 is transmitted to the worm wheel 144 to lower or raise the output speed of the worm wheel 144. The turning of the wheel gear 144 is transmitted to the output shaft 145 of the actuator. A first bearing 146A is mounted on the output shaft 145. A second bearing 146B will be described later with reference to Fig. 4.

[0016] The electronically controlled actuator in the preferred embodiment is used for the positional control of the movable vanes of a turbocharger, i.e., a driven member. The position sensor 150 is provided to measures the position of the movable vanes. The position sensor 150 comprises magnetic plates (encoder disks) 151 and 152 and Hall ICs 153 and 154, which will be described later with reference to Fig. 3. The magnetic plates 151 and 152 are fixedly mounted on the output shaft of the motor 130 coaxially with the same. As shown in Fig. 3, the Hall ICs 153 and 154 are attached to a control circuit 160 at positions opposite to the peripheral edges of the magnetic plates 151 and 152, respectively. The magnetic flux densities of magnetic fields created by the magnetic plates 151 and 152 and applied to the Hall ICs 153 and 154 vary as the magnetic plates 151 and 152 rotate. The outputs of the Hall ICs 153 and 154 can be changed between high and low by changing the magnetic flux densities. The position sensor 150 is a magnetic encoder consisting of the magnetic plates 151 and 152, and the Hall ICs 153 and 154.

[0017] The magnetic plates 151 and 152 are formed of, for example, a resin, such as PPS, so that the magnetic plates 151 and 152 have a small moment of inertia when rotated by the motor to reduce a delay in starting the motor while the actuator is stopped. The magnetic plates 151 and 152 are fixedly mounted on the output shaft of the motor 130 or the pinion 141 with an adhesive. The magnetic plates 151 and 152 may be formed integrally with the output shaft of the motor 130 or the pinion 141.

[0018] Magnets are embedded in the magnetic plates 151 and 152 at equal angular pitches such that the same magnetic poles lie in a peripheral part of the magnetic plates 151 and 152. Magnetic flux densities of magnetic fluxes applied to magnetic flux measuring devices, not shown, included in the Hall ICs 153 and 154 are changed alternately to make the Hall ICs 153 and 154 go on and off. The variation of the magnetic flux produced by the magnetic plate 151 varies the output of the Hall IC 153, the variation of the magnetic flux produced by the magnetic plate 152 varies the output of the Hall IC 154.

[0019] The phase difference between the respective output phases of the magnetic plates 151 and 152 is a quarter of the period. It is possible to know whether the output shaft of the motor 130 is rotating in the normal direction or in the reverse direction from the mode of superposition of the on-off patterns.

[0020] The working angle of the movable vane of the turbocharger is physically controlled such that the working angle of the movable vanes varies as a function of the number of output pulses provided by the position sensor 150, i.e., the magnetic encoder. For example, the relation between the working angle of the movable vanes and the number of output pulses provided by the position sensor 150 is expressed by Expression (1), where θ_v is the working angle of the movable vanes, P is the number of pulses, n is the total speed reduction ratio of the speed change mechanism consisting of the pinion 141, the gear 142, the worm 143 and the worm

wheel 144, and θ_e is the angular pitch of the magnets of the magnetic plate 151.

$$\theta_v = P \times (\theta_e/n) \quad (1)$$

[0021] The number P of the output pulses is an integer, and θ_e/n indicates the angular resolution of the actuator in this embodiment. When it is desired that the rotating speed of the output shaft 145 is higher than that of the output shaft of the motor 130, the total speed reduction ratio n is smaller than 1 for speed increasing. The motor 130 employed in the actuator in this embodiment is a small, high-speed, low-torque motor. Therefore, the total speed reduction ratio n > 1, to drive the output shaft 145 by a desired torque for rotation at a desired rotating speed. In this embodiment, the magnetic plate 152 is used only for determining the rotating speed of the output shaft of the motor 130 on the basis of the output phase difference. Since a pulse signal of a period equal to a quarter of the period of pulses provided by only the Hall IC 153 can be obtained by performing a logical AND operation between the outputs of the Hall ICs 153 and 154 driven by the magnetic plates 151 and 152, the angular resolution may be further raised.

[0022] As apparent from the foregoing description, this embodiment is characterized in that the magnetic plates 151 and 152 forming the position sensor 150 are mounted on the output shaft of the motor 130. In the prior art actuator, the position sensor is mounted on the output shaft of the speed change mechanism and hence the reliability is reduced when the output shaft of the speed change mechanism vibrates. In this embodiment, the position sensor is mounted on the output shaft of the motor and measures the angle of rotation of the output shaft of the motor to control the output shaft of the actuator. Accordingly, the vibration of the output shaft of the actuator is not transmitted to the position sensor and hence the reliability can be improved. It may be also said that the positions of the magnetic plates 151 and 152 are on the input shaft of the speed change mechanism 140.

[0023] When the speed change mechanism 140 is a reduction gear, the position of the position sensor 150 is on the side of the power source (motor 130) with respect to the reduction gear (total speed reduction ratio n). Therefore, the sensor resolution may be 1/n of the angular resolution necessary for controlling the output shaft, sensitivity to erroneous measurement due to runout caused by vibrations is low, and hence erroneous measurement occurs scarcely. Thus, the erroneous position measurement of the position sensor can be avoided. The overall resolution of the position sensor can be multiplied by n if the sensor resolution of the magnetic plate is the same as the conventional one.

[0024] Referring to Fig. 2, a link 147 is fixedly mounted on the output shaft 145. A swing motion of the link 147, which will be described later with reference to Fig. 5, is transmitted by a link 292 to a turbocharger 200 to operate the movable vanes 230 of the turbocharger 200 for position control. A cover 148 is joined to a base part of the link 147 to prevent the entry of external dust into the actuator 100.

[0025] The cover 120 will be described in connection with Fig. 3. The cover 120 is joined to the body 110 fixedly holding the motor 130 and the speed change mechanism 140 therein as shown in Fig. 2 to protect the motor 130, the speed change mechanism 140 and the position sensor 150 from external moisture, oil and dust. The cover 120 has the following functions.

[0026] As shown in Fig. 1, the power supply connector 121 is formed integrally with the cover 120 to supply power to the motor 130 and the control circuit 160. Terminals of the power supply connector 121 are connected to the terminals of the control circuit 160 with aluminum wires 122A by vibration welding (wire bonding). Power is supplied from an external power source through the power supply connector 121 and the aluminum wires 122A to the control circuit 160. Terminals of the control circuit 160 are connected to motor terminals 123A and 123B with aluminum wires 122B by wire bonding.

[0027] The motor 130 is provided with two female terminals 131B as shown in Fig. 1, in which only one of the two female terminals 131B is shown. The motor terminals 123A and 123B are embedded in the cover 120. The motor terminals 123A and 123B embedded in the cover 120 come into electrical contact with the female terminals 131B when the cover 120 is joined to the body 110. Power applied to the power supply connector 121A is supplied through the control circuit 160 and the motor terminals 123A and 123B to the motor 130.

[0028] The cover 120 is integrally provided with a rectangular partition wall 124. The control circuit 160 is fixed to the cover 120 with an adhesive or the like in a space 125 surrounded by the partition wall 124. The control circuit 160 is bonded to a flat part of the cover 120 in the space 125 with, for example, an epoxy adhesive. The space 125 is isolated from a bearing holding part 126 formed in the cover 120 by the partition wall 124. A control circuit cover 127 is bonded to the end surface of the partition wall 124 with an adhesive to isolate the control circuit 160 from a space around the bearing holding part 126. Thus, the contamination of the control circuit 160 with particles produced by the abrasion of the bearing when the output shaft 145 rotates or with scattered grease and troubles in the circuit due to short circuit can be prevented.

[0029] A bearing structure for supporting the output shaft 145 of the actuator 100 will be described with reference to Fig. 4. As shown in Fig. 4, the output shaft is supported in the two ball bearings 146A and 164B. The first ball bearing 146A has an outer race held in the bearing holding part 126 formed of the same material as that

of the cover 120 integrally with the cover 120. The first ball bearing 146A sustains axial and radial loads. The outer race of the ball bearing 146A is fitted in the bearing holding part 126 in a clearance fit. The inner race of the ball bearing 146A is mounted on the output shaft 145 in a press fit. The second ball bearing 146B has an outer race fitted in a bearing holding part of the body 110 in a press fit, and an inner race mounted on the output shaft 145 in a press fit. The link 147 is mounted on an output end part of the output shaft 145, and the output end part is covered with the watertight cover 148 to prevent the entry of moisture in the actuator when the actuator is splashed with water.

[0030] In this embodiment, the position sensor 150 is combined with the output shaft of the motor 130 as shown in Fig. 1. Therefore, the two bearings (the ball bearings 146A and 146B) can be held on the body 110 and the cover 120, respectively, the two bearings can be spaced the longest possible distance apart, and hence the vibration of the output shaft caused by the vibration of the internal combustion engine can be limited to the least extent. Consequently, fretting abrasion can be limited to the least extent and the durability of the actuator can be enhanced. Since the opposite ends of the output shaft 145 are supported in the ball bearings, an increase in resistance against the sliding motion of the bearing parts can be limited to the least extent when an offset load is applied to the output shaft 145 in a direction perpendicular to the axis of the output shaft 145.

[0031] A variable-capacity turbocharger provided with the electronically controlled actuator in this embodiment will be described with reference to Figs. 5 to 8.

[0032] Fig. 5 is a perspective view of a variable-capacity turbocharger provided with the electronically controlled actuator in this embodiment. Fig. 6 is a end view of the variable-capacity turbocharger provided with the electronically controlled actuator in this embodiment showing the arrangement of vane links in a turbine housing. Fig. 7 is a view showing the arrangement of variable vanes of the variable-capacity turbocharger provided with the electronically controlled actuator in this embodiment. Fig. 8 is a sectional view taken on line X-X in Fig. 7. In Figs. 5 to 8, the same reference characters designate the same parts, respectively.

[0033] Referring to Fig. 5, the electronically controlled actuator 100 is fastened t a bracket 290 fixed to a variable-capacity turbocharger 200 with screws or the like. The variable-capacity turbocharger 200 has a turbine housing 210 and a compressor housing 220. The electronically controlled actuator 100 is fastened to the bracket 290 fixed to the compressor housing 220 with screws or the like. Exhaust gases discharged from an internal combustion engine flows through the turbine housing 210 and hence the turbine housing 210 is heated at a high temperature. Since temperature rise in the compressor housing 220 is comparatively small, heat transfer from the turbine housing 210 to the electronically controlled actuator 100 can be avoided. The bracket 290 serves also as a shield for intercepting radiant heat emitted by the turbine housing 210.

[0034] The link 147 of the electronically controlled actuator 100 is connected to a rod 294 supported on the turbine housing 210 by a movable link 292. Thus, the turning motion of the output shaft of the electronically controlled actuator 100 is transmitted through the movable link 292 to the rod 294.

[0035] A drive link 232 shown in Fig. 6 is connected to the rod 294 shown in Fig. 5 coaxially with the rod 294. As shown in Fig. 6, a turning motion of the drive link 232 is transmitted to a ring 234 to turn the ring 234. A plurality of vane links 236 arranged on a circle in the turbine housing 210 are turned through the same angle by the ring 234 when the ring 234 is turned.

[0036] As shown in Fig. 7, the plurality of movable vanes 230 are supported for turning on the turbine housing 210. As shown in Fig. 8, the movable vanes 230 are connected coaxially to the vane links 236. The movable vanes 230 turn when the vane links 236 are turned. Thus, the turning motion of the output shaft of the electronically controlled actuator 100 turns the movable vanes 230 to control the flow of the exhaust gases flowing through the turbine housing 210.

[0037] A control system for controlling the variable-capacity turbocharger provided with the electronically controlled actuator in this embodiment will be described with reference to Fig. 9.

[0038] Fig. 9 shows a system including the variable-capacity turbocharger 200 provided with the electronically controlled actuator in this embodiment. In Figs. 1 to 8, the same reference characters designate the same parts.

[0039] The plurality of movable vanes 230 are arranged in the turbine housing 210 of the variable-capacity turbocharger 200. The movable vanes 230 are supported for turning and are interlocked with the movable link 292. The movable link 292 is connected pivotally to the output shaft of the actuator 100.

[0040] The flow of the exhaust gases through the turbine housing 210 is adjusted by adjusting the angular position of the movable vanes 230 to adjust compression pressure of the compressor to a desired value. The operation of the electronically controlled actuator 100 is controlled by the control circuit 160 included in the actuator and fixed with the adhesive to a part of the actuator. The control circuit 160 compares measured position data provided by the position sensor included in the actuator, and desired position data represented by a signal received from a engine control unit (ECU) 300 included in the internal combustion engine, and controls the actuator 100 according to the difference between the measured and the desired position data.

[0041] As obvious from the foregoing description, in the embodiment of the present invention, the output shaft is supported for rotation in the first bearing on the body and in the second bearing on the cover, and the

position sensor is combined with the output shaft of the motor. Thus, the position sensor is combined with the output shaft of the motor, measures the angle of rotation of the output shaft of the motor to control the output shaft of the actuator. Therefore, the vibration of the output shaft of the actuator is not transmitted to the position sensor and hence the reliability is improved. Since the two bearings are held on the body and the cover, respectively, the two bearings can be spaced the longest possible distance apart, and hence the vibration of the output shaft can be limited to the least extent. Consequently, fretting abrasion can be limited to the least extent and the reliability of the actuator can be improved.

[0042] Since the cover is provided with the power supply connector for supplying power to the motor and the bearing supporting one end of the output shaft is held on the cover, the cover is able to serve as both a connector and a bearing.

[0043] Since the motor terminals 123A and 123B to be connected to the power supply terminals of the motor are embedded in the cover, both supporting the output shaft and electrically connecting the motor to the power supply terminals can be achieved by joining the cover to the body.

[0044] Since the control circuit for controlling the motor is held on the cover, the bearing supporting the one end of the output shaft is held on the cover, and the cover is provided with the partition wall isolating the control circuit from the bearing, the control circuit held on the cover can be prevented from contamination with the lubricant lubricating the bearings supporting the output shaft.

[0045] Since the position sensor is combined with the output shaft of the motor coaxially with the same, the angular position of the movable vanes are hardly affected by disturbances (temperature and vibration) and can be accurately measured, and the angular position of the movable vanes of the turbocharger can be accurately controlled.

[0046] Since the output shaft has the opposite ends supported for rotation in the first and the second bearing, the vibration of the output shaft can be limited to the least extent, fretting abrasion can be limited to the least extent and the reliability can be improved.

[0047] Since the output shaft has the opposite ends supported for rotation in the first and the second bearing, and the angular position of the movable vanes of the turbocharger is controlled on the basis of the output of the position sensor of the electronically controlled actuator, the reliability of the turbocharger with electronically controlled actuator can be improved.

[0048] According to the invention stated in claim 1, the durability of the actuator can be enhanced and the reliability of the actuator can be improved.

[0049] According to the invention stated in claim 2, the cover is provided with the power supply connector for supplying power to the motor, and the bearing supporting one end of the output shaft is held on the cover. Therefore, the cover serves also as both a connector and a bearing.

[0050] According to the invention stated in claim 3, Since the cover is provided with the connecting terminals to be plugged in and connected to the power supply terminals formed on the motor, both supporting the output shaft in the bearing and electrical connection of the connecting terminals to the motor can be simultaneously achieved by attaching the cover to the body.

[0051] According to the invention stated in claim 4, since the motor control circuit is attached to the cover and the bearing held on the cover supports one end of the output shaft, and the cover is provided with the partition wall separating the bearing from the control circuit, the control circuit attached to the cover can be protected from contamination with a lubricant lubricating the bearing supporting the output shaft.

[0052] According to the invention stated in claim 5, since the position sensor is disposed coaxially with the output shaft of the motor, the angular position of the movable vanes of the turbine of the turbocharger is hardly affected by disturbances (temperature and vibration) and can be accurately measured, and the angular position of the movable vanes of the turbocharger can be accurately controlled.

[0053] According to the invention stated in claim 6, since the opposite ends of the output shaft are supported in the first and the second bearing, respectively, the vibration of the output shaft can be limited to the least extent, fretting abrasion can be limited to the least extent and the reliability can be improved.

[0054] According to the invention stated in claim 7, since the opposite ends of the output shaft are supported in the first and the second bearing, respectively, and the angular position of the movable vanes of the turbocharger is controlled on the basis of the output of the position sensor of the electronically controlled actuator, the reliability of the turbocharger with electronically controlled actuator can be improved.

[0055] According to the invention stated in claim 8, the resin cover serves also as both an electric connector and a bearing holder.

[0056] According to the invention stated in claim 9, the output shaft can be supported and the motor can be electrically connected to the electric terminals by attaching the resin cover to the body.

[0057] According to the invention stated in claim 10, the control circuit attached to the resin cover can be protected from contamination with a lubricant lubricating the bearing supporting the output shaft.

[0058] According to the invention stated in claim 11, the angular position of the movable vanes of the turbine can be accurately controlled regardless of disturbances (temperature and vibration).

[0059] According to the invention stated in claim 12, the functions of both the control circuit for controlling the motor of the actuator of the movable-vane turbine and a rotation sensor are available.

[0060] According to the invention stated in claim 13, the contamination of the magnetoelectric conversion device with grease lubricating the bearings and powder produced by abrasion can be suppressed.

[0061] According to the invention stated in claim 14, the resin cover is able to hold the control circuit for controlling the motor of the actuator for the movable-vane turbine, part of the rotation sensor, and the bearing.

[0062] While the invention has been described in its preferred embodiments, it is to be understood that the words which have been used are words of description rather than limitation and that changes within the purview of the appended claims may be made without departing from the true scope and spirit of the invention in its broader aspects.

Claims

1. An electronically controlled actuator for driving a driven member for rotation comprising:

    a motor (130);
    a speed change gear (140) including an output shaft (145) driven by the motor (130) and capable of driving the driven member (230);
    a position sensor (150); and
    a case including a body (110) and a cover (120), and containing the motor, the speed change gear and the position sensor;

    wherein a first bearing (146A) supporting the output shaft for rotation is held on the cover (120), a second bearing (146B) supporting the output shaft (145) for rotation is held on the body (110), and the position sensor (150) is mounted on the output shaft of the motor.

2. An electronically controlled actuator for driving a driven member for rotation comprising:

    a motor (130);
    a speed change gear (140) including an output shaft (145) driven by the motor (130) and capable of driving the driven member (230);
    a position sensor (150); and
    a case including a body (110) and a cover (120), and containing the motor (130), the speed change gear (140) and the position sensor (150);

    wherein a power supply connector (121) for supplying power to the motor is formed on the cover (120), a bearing (146A) held on the cover (120) supports one end of the output shaft (145), and the driven member is a turbocharger (200).

3. An electronically controlled actuator for driving a driven member for rotation comprising:

    a motor (130);
    a speed change gear (140) including an output shaft driven by the motor (130) and capable of driving the driven member (200; 230);
    a position sensor (150);
    a case including a body (110) and a cover (120), and containing the motor (130), the speed change gear (140) and the position sensor (150);

    wherein connecting terminals to be plugged in power supply terminals (121) formed on the motor (130) are formed on the cover (120), a bearing (146A) held on the cover (120) supports one end of the output shaft (145), and the driven member is a turbocharger (200).

4. An electronically controlled actuator for driving a driven member for rotation comprising:

    a motor (130);
    a speed change gear (140) including an output shaft (145) driven by the motor (130) and capable of driving the driven member (200);
    a position sensor (150); and
    a case including a body (110) and a cover (120), and containing the motor (130), the speed change gear (140) and the position sensor (150);

    wherein a motor control circuit (160) is attached to the cover (120), a bearing (146A) held on the cover (120) supports one end of the output shaft, and the cover (120) is provided with a partition wall (124) separating the bearing (14A) from the control circuit (160).

5. An electronically controlled actuator for driving a driven member for rotation comprising:

    a motor (130);
    a speed change gear (140) including an output (145) shaft driven by the motor (130) and capable of driving the driven member (200);
    a position sensor (150); and
    a case including a body (110) and a cover (120), and containing the motor (130), the speed change gear (140) and the position sensor (150);

    wherein the position sensor (150) is mounted on the output shaft of the motor coaxially with the output shaft (145), the driven member is a turbocharger (200), and the angular position of the movable vanes (230) of the turbocharger (200) is controlled on the basis of the output of the position sensor

(150).

6. An electronically controlled actuator for driving a driven member for rotation comprising:

a motor (130);
a speed change gear (140) including an output shaft (145) driven by the motor (130) and capable of driving the driven member (200);
a position sensor (150); and
a case including a body (110) and a cover (120), and containing the motor (130), the speed change gear (140) and the position sensor (150);

wherein the output shaft (145) has opposite ends supported in first and second bearings (146A; 146B), respectively, the driven member is a turbocharger (200), and the angular position of the movable vanes (230) of the turbocharger (200) is controlled on the basis of the output of the position sensor (150).

7. A turbocharger with electronically controlled actuator (100) comprising:

an electronically controlled actuator comprising:

a motor (130);
a speed change gear (140) including an output shaft (145) driven by the motor (130);
a position sensor (150); and
a case including a body (110) and a cover (120), and containing the motor, the speed change gear and the position sensor; and
a turbocharger (200) having movable blades (230);

wherein the output shaft (145) has opposite ends supported in first and second bearings (146A; 146B), and the angular position of the movable vanes (230) of the turbocharger is controlled on the basis of the output of the position sensor (150) of the electronically controlled actuator (110).

8. An electric actuator comprising:

a body (110);
a motor (130) held on the body;
an output shaft (145);
a gearing (140) for transmitting the rotation of the output shaft of the motor (130) to the output shaft (145) to drive the output shaft (145) for rotation;
a bearing (146) held on the body (110) and supporting one end of the output shaft (145); and
a resin cover (120) fixed to the body (110) so as to cover the motor, the gearing and the other end of the output shaft (145);

wherein the cover (120) is provided with a power supply connector (121) for supplying power to the motor (130) on its outer surface, and terminals electrically connected to the power supply connector and to the motor on its inner surface, and a bearing (146A) has an inner race fixedly mounted on the other end of the output shaft (145) and an outer race fixed to the cover (120).

9. An electric actuator comprising:

a body (110);
a motor (130) held on the body (110);
an output shaft (145);
a gearing (140) for transmitting the rotation of the output shaft of the motor (130) to the output shaft (145) to drive the output shaft for rotation;
a bearing (146B) held on the body (110) and supporting one end of the output shaft (145); and
a resin cover (120) fixed to the body (110) so as to cover the motor, the gearing and the other end of the output shaft;

wherein the resin cover (120) is provided with electric terminals (121A) capable of being plugged in and connected to the power supply terminals of the motor and combined therewith by molding, and with a bearing holding part (126) for holding an outer race included in a bearing (146A) having an inner race fixedly mounted on the other end of the output shaft (145).

10. An electric actuator comprising:

a body (110);
a motor (130) held on the body (110);
an output shaft (145);
a gearing (140) for transmitting the rotation of the output shaft of the motor to the output shaft to drive the output shaft (145) for rotation;
a bearing (146B) held on the body (110) and supporting one end of the output shaft (145); and
a resin cover (120) fixed to the body (110) so as to cover the motor, the gearing and the other end of the output shaft;

wherein a control circuit (160) for controlling the motor is attached to the inner surface of the resin cover (120) and is electrically connected to a connector (121) formed on the outer surface of the resin cover (120), and the resin cover is provided with a partition wall (127) holding an outer race included in a bear-

ing (146A) having an inner race fixedly mounted on the other end of the output shaft (145) and separating the control circuit (160) from the bearing (146A).

11. A movable-vane turbine comprising:

movable vanes (230);
a motor (130); and
an output shaft (145) driven for rotation by the motor (130) and capable of controlling the angular position of the movable vanes (230);

wherein a magnetic encoder is combined with the output shaft of the motor (130), the angular position of the movable vanes (230) is physically controlled such that the angular position of the movable vanes varies as a function of the number of output pulses provided by the magnetic encoder (151 - 154).

12. A movable-vane turbine comprising:

movable vanes (230);
a motor (130);
an output shaft (145) driven for rotation by the motor (130) and capable of controlling the angular position of the movable vanes; a gearing (140) for transmitting the rotation of the output shaft of the motor to the output shaft (145) to drive the output shaft for rotation;
a body (110) holding the motor (130) and provided with a bearing (146A) supporting one end of the output shaft (145); and
a resin cover (120) fixed to the body (110) so as to cover the motor, the gearing and the other end of the output shaft;

wherein a magnetic encoder (151, 152) is combined with the output shaft of the motor (130), a control circuit (160) for controlling the motor is attached to a part opposite to the magnetic encoder (151, 152) of the inner surface of the resin cover (120) and is connected electrically to a connector formed on the outer surface of the resin cover, and a magneto electric conversion device (153, 154) for measuring the variation of the magnetic flux of the magnetic encoder is attached to the control circuit.

13. The movable-vane turbine according to claim 12, wherein the resin cover (120) is provided with a partition wall (127) for separating the magneto electric conversion device from the magnetic encoder.

14. The movable-vane turbine according to claim 12, wherein electric terminals of the motor, and a bearing mount for supporting a bearing (146A) supporting the other end of the output shaft (145) are formed on the inner surface of the resin cover (120) on the opposite sides of the control circuit (160), respectively.

FIG.1

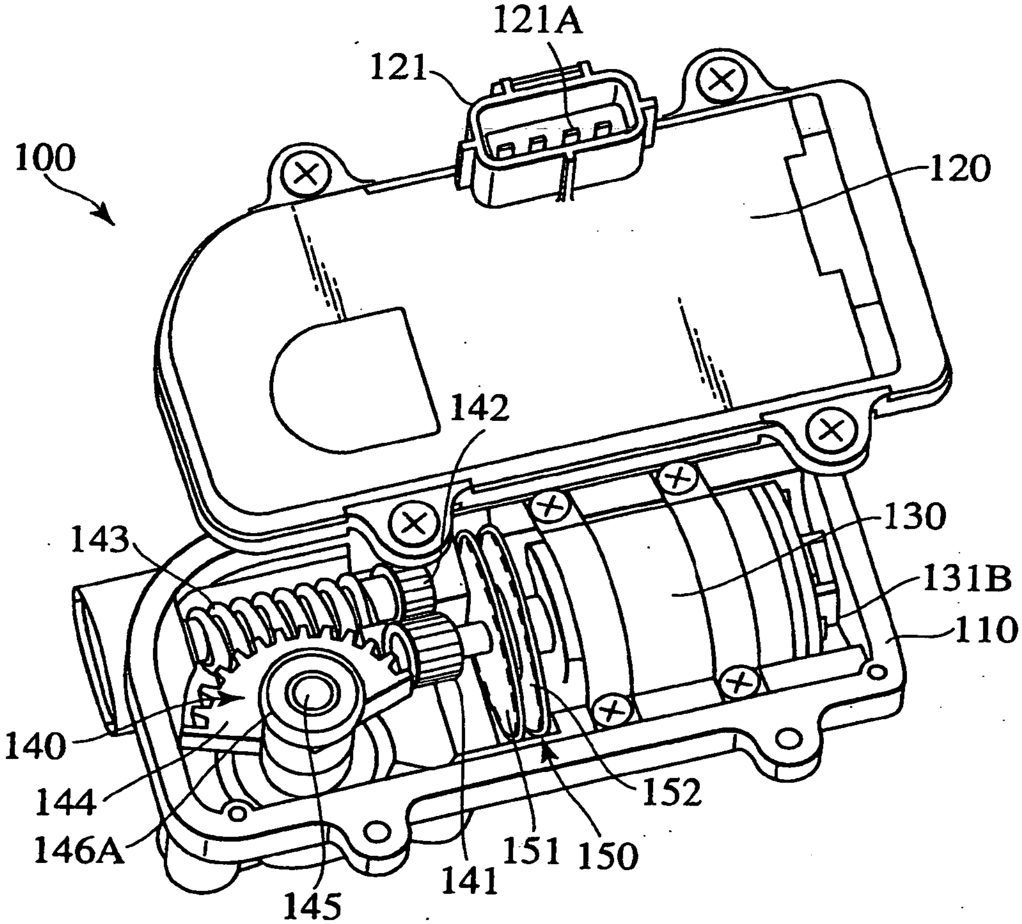
121A
121
100
120
142
143
130
131B
110
140
144
146A
145
141
151
150
152

FIG.2

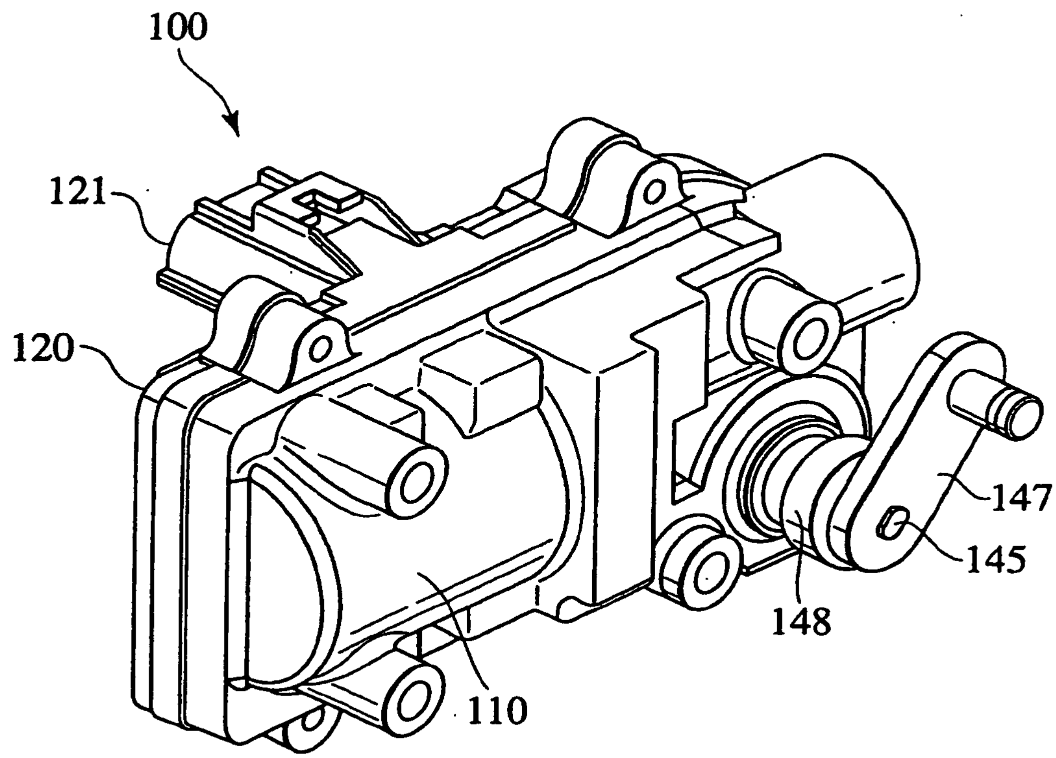

FIG.3

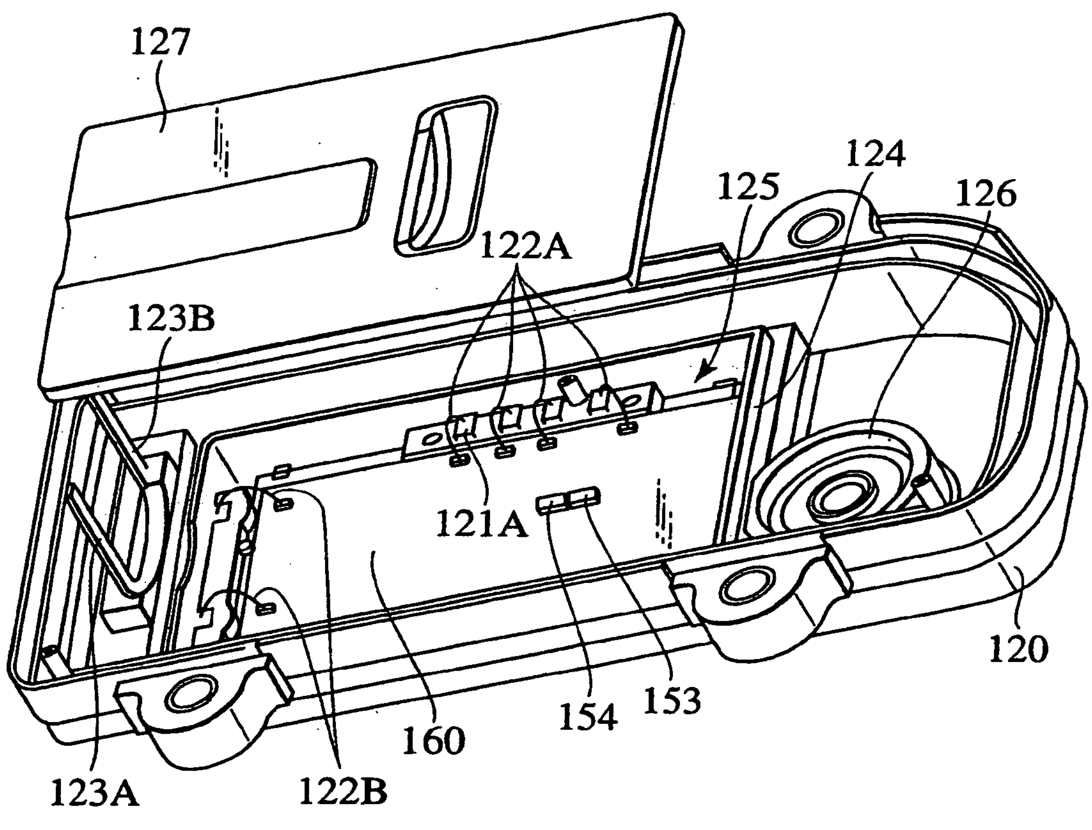

FIG.4

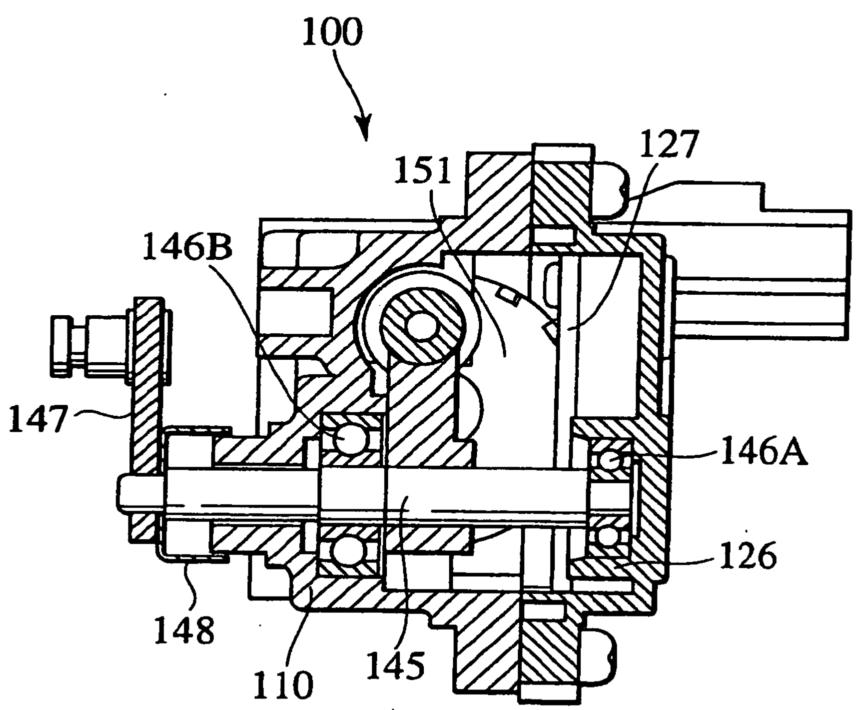

FIG.5

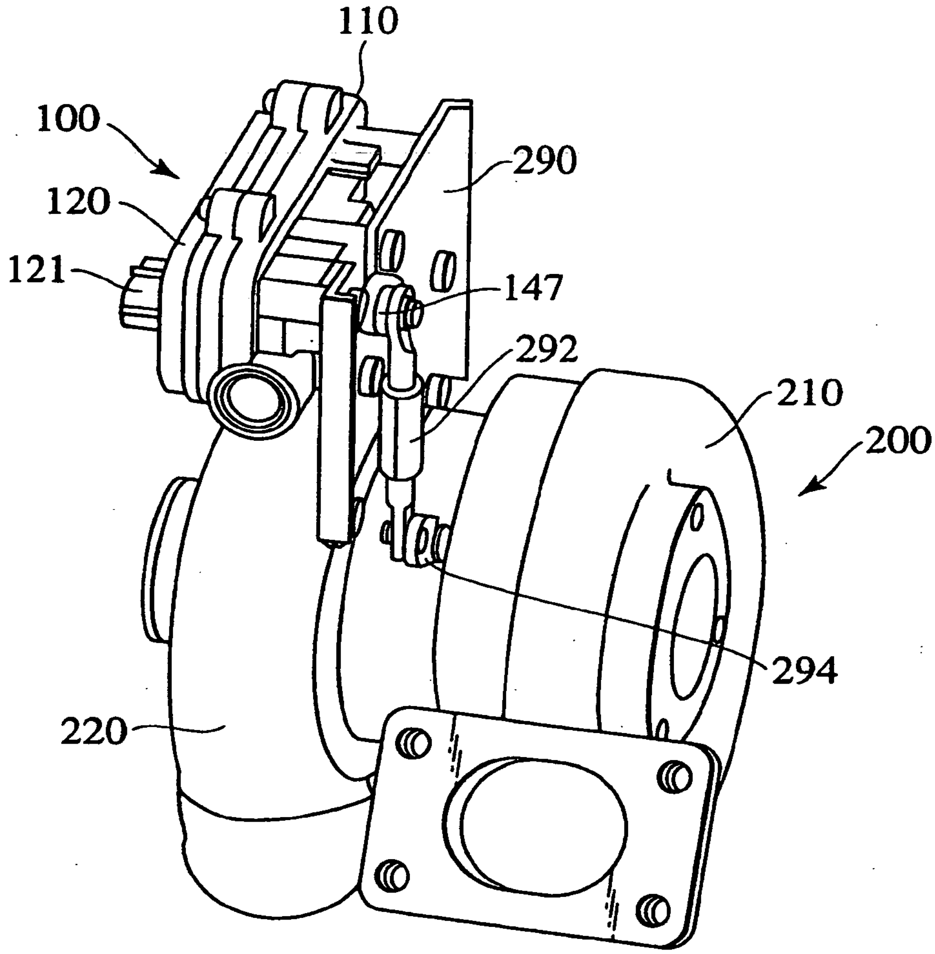

FIG.6

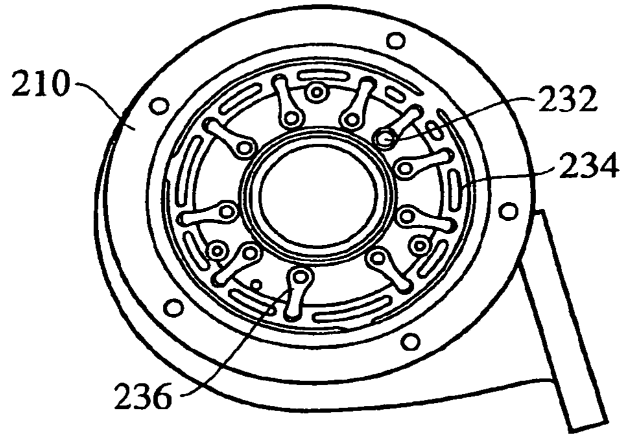

FIG.7

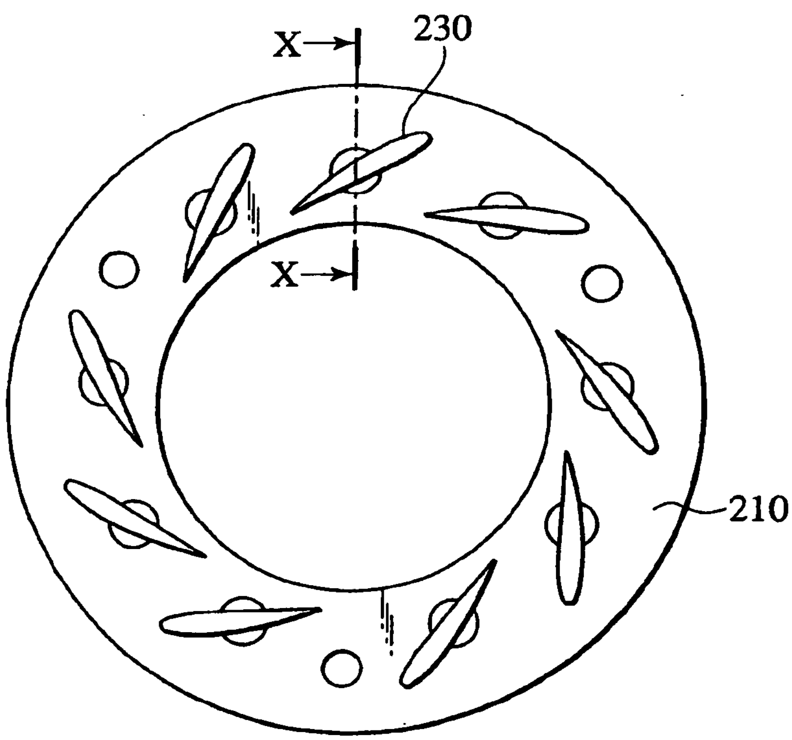

FIG.8

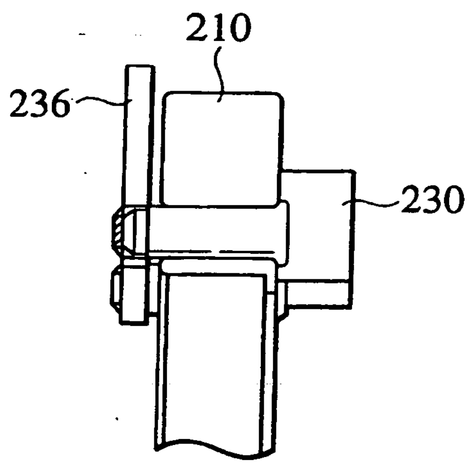

FIG.9